DE HAVILLAND DH89 RAPIDE
by Ivan Pettigrew
Construction Notes

The Rapide is sometimes claimed to be the most efficient biplane ever built. Interference between the wings of a biplane decreases their efficiency, but this loss is minimized by making the gap between the wing as large as possible in relation to the wing chord. Because of the high aspect ratio of the Rapide wings, the gap between them is quite considerable in terms of wing chord, especially towards the tips where the chord decreases. In addition to this, it will be noted that there is negative dihedral in the lower wing between the centre section and a point just outboard of the engine nacelle. Apart from adding "character" to the design, it moves the outboard sections of the wing even further apart, thus reducing interference between the wings and improving their efficiency a tad more.

My introduction to electric models was with a two metre powered glider, the Goldberg Electra. When designing the Rapide, I thought of it as a "double 2m glider." Each wing was about the same span and area as a two metre glider, it used two of the same kind of can motors, and two seven-cell 1400 mAh battery packs of the same type as used in the Electra. The motors and battery packs were wired in series, this being equivalent to running each motor from seven cells. The weight however was somewhat over double that of a two metre glider, but the model was a good flyer right from the start. After flying for a few years in this configuration, the original "can" motors were replace by 27 turn "stock" racing car motors. It was later found that these motors run very efficiently on nine cells and low amperage, so the motor wiring was changed from series to parallel, and the motors were run from one battery pack of nine 1700 mAH SCR cells. This resulted in considerable weight saving, and the model flew at a slower more scale like speed. The weight was now down to about double that of a 2M electric glider. It was expected that flight duration might suffer when flying on just nine cells, but this was not the case, since it seems that the efficiency of the motors is so much better and at the lighter weight, less power is needed for cruise flight. For future builders, the 22 turn Magnetic Mayhem motor is recommended. It has a slightly longer armature and can than most racing car motors, and is very efficient operating on nine cells in the area of 15 amps as it would in this model. The Magnetic Mayhem motor comes with normal, or reverse timing. If using a single stage gearbox which changes the direction of rotation, it is important that the "reverse" motor is used.

The prototype model of the Rapide was built with the lower wing in three sections. The outer panel of each lower wing could be removed where the dihedral changes just outboard of the engine nacelle. The top wing was built in one section. For transportation of the model, the centre section of the lower wing was normally left attached to the fuselage along with the motors and undercarriage. Assembly at the field is very quick and does not require any tools, since the wing outer panels, and wing struts are all held in place with nylon clips which snap into place. The plan shows two nylon clips being used to secure the outer wing panels, one at the location of the main spar, and the other at the secondary spar. In later designs with much larger wings, it has been found that just one clip located at the main spar is quite sufficient to secure the outer panel. Making the lower wing in three sections makes for more construction time and a little added weight, so some builders may prefer to make the lower wing in one piece, and remove it (complete with motors and undercarriage) for transportation.

The full scale Rapide had ailerons on both upper and lower wings. Because of the difficulty of operating ailerons on the removable outer panels of the lower wing, the prototype model of the Rapide just had ailerons on the top wing. This proved to be quite satisfactory. In this respect it is like the D.H. Dragonfly which was a mini version of the Rapide. One advantage to building the lower wing in one piece is that it would simplify aileron linkage. In more recent designs, an easy way has been devised to have operating ailerons on removable outboard wing panels. The aileron bell crank would be located in the last bay of the centre panel between ribs 5 and 6. The ailerons would run the full length of the removable outboard panel, and the aileron control horn would be located at the extreme inner end, next to the rib 6 location. The pushrod from the bell crank would then run at a slight angle across the join in the wing sections, the clevis on the aileron control horn being disconnected before removing the outer panel. If ailerons are desired in both top and bottom wings, a servo could be mounted in each wing and run parallel with a “Y” connector to the radio. Outboard aileron servos are not recommended for multi motor electric models. They require long leads, and because of running parallel to the motor wiring which carries high amperage, they are prone to pick up interference.

FUSELAGE

This is of typical “box” construction. The two sides are built over the shaded part of the plan and then joined together. Stringers along the sides and top are added later. Note that the cockpit area is made so as to be removable. This gives access to the battery area. A note is written on the plan regarding the motor battery location. When using just one nine cell pack, it has to be about two inches forward from the location shown for 14 cells. The nose section of the fuselage is built up from 1/16” balsa sheet which is shaped around a large old style car head lamp bulb which represents the landing light that was mounted in this position.

TAIL SECTIONS

The tail sections use a symmetrical airfoil section. This gives a deeper spar which adds strength. The end result is that a tail surface can be built lighter this way, and is less prone to warping than a flat surface. Make up the spars and locate the hinges to get a good fit before proceeding with construction.

WING CONSTRUCTION
The top wing is of conventional construction, the dihedral break being at the centre. Plywood doublers are used at the dihedral break, and webbing applied between the wing spars as shown from the centre of the wing out to rib #12. The lower wing is more challenging. There is a dihedral break at the side of the fuselage, and then outboard of the engine nacelles. The panels need to be built separately and joined, using the plywood doublers on the spar as shown on the plan. Because of the stagger of the wings, the main landing gear wheels are located much further forward of the lower wing than would be the case in a monoplane. This results in considerable twisting (torsional force) of the lower wing in the section between the fuselage and engine nacelles when the weight of the plane is placed on the landing gear. Hence it is important that 1/16" sheet is applied to the upper and lower surface of the wing between the leading edge and the main spar. Along with the webbing between the main spars, this makes for a "D" box which will resist this twisting force.

The following instructions have been added for those not familiar with the "sandwich" method mentioned on the plan for making the wing ribs:

"It used to be on tapered wings that the only ribs shown were the one at the root and the one at the tip. The rest were roughed out a little oversize, pinned together side by side with the root at one end and the tip at the other. Then they are shaped down to size. I have found it easier to do it in small clusters of just a few ribs at a time, doing for instance #1 to #4 first, then #4 to the next one shown which is #6, pinning the rids together with oversize blanks between the first and last ribs. With the Rapide there are no more than two or three of the "in between" ribs to shape that way and it is almost quicker than tracing out the shape of every rib individually. When shaped, place each rib over the plan of the wing to mark the location of the cut outs for spars and aileron."

The motor mounts and landing gear pedestal s are next built using hardwood strips which are glued in place in the sequence shown on the plan as #1 through #5. Epoxy should be used for gluing these strips in place, since there is considerable stress in the area of the undercarriage. The section of the landing gear leg between the nylon mounting straps acts as a torsion bar. With the raked back nature of the landing gear leg, it means that when the wheel hits a bump, besides moving backward, it goes "up" slightly. This makes for good absorption of bumps. To hold the landing gear wire in place, the upper end of the leg is bound with thread to hardwood strip #3 and glued. Next the nacelle bulkheads are glued in place, and the nacelles planked with 1/16" sheet balsa. Note that small hardwood blocks are glued to the front surface of M-2. These are for locating the small #2 screws that hold the cowlings in place.

The engine cowlings are built in place with the motors installed. First the nose blocks are made, but the hole for the propeller shaft should at this point be made just large enough for the nose block to be a snug fit over it. This will hold the nose block in place while the cowlings are built, and later on the hole for the propeller shaft can be enlarged. With the nose block held in place by the propeller shaft, start making the cowls by cutting out the side panels. These are attached with screws to the hardwood blocks on M2 at the rear, and glued at the front to the nose block. Next apply the top and bottom parts of the cowling, gluing these to the nose block and adjacent side panel sections, but not of course to the "M" bulkheads. When the glue is dry, take out the screws and remove the cowlings. Now the hole in the nose block for the propeller shaft can be enlarged to give adequate clearance. Before covering the cowlings, small washers should be made from 1/64" ply and placed under the heads of the #2 screws that hold the cowlings in place.

In multi motor electric models, there is an increased risk of problems with radio interference from motor brush noise and also the increased length of wiring used for the motors. While it is always recommended to put a Schotky diode across the terminals of each motor when they are wired in series, it is not so critical when the motors are wired parallel. The normal capacitors should of course be used across the motor terminals, whether or not Schotky diodes are used. The wires carrying current to the motor should be kept touching each other, and twisted about one turn to the inch. The radio and servos should be kept as far as possible from the motors and motor wiring. Servo leads must be kept short.

COVERING AND FINISHING

Most of the airframe on the prototype is covered with low temperature film. This type of film is less prone to warp the lightweight type of airframe construction. Mica film is a good choice for the lower surface of the wings. It is extremely strong, and adds strength to the wing when used in this manner. Clear transparent monokote is used for the windows. This should be applied before the regular covering. The only window area which is different is the curved part above the windshield. Mylar film as used for overhead transparencies is good for this section.

The plan shows the method of attaching the wing struts using nylon snap fasteners. In this manner, no tools are required for assembly. Another option that is used more in recent times is rare earth magnets. These are available in a small size and are extremely powerful. One of our local flyers uses them to secure the struts (and wings) in a small model of the Fokker triplane which he flies indoors. If he hits a wall, the whole plane seems to come apart, but the laugh is on the "first time" spectators as they watch him put the pieces together in a few seconds and launch the model for another round of flying. This type of operation is not recommended for the Rapide, but it is a fun plane to fly.

Be sure to get plenty of differential into the ailerons. The first item of importance is to make up the servo arm as shown. The upgoing aileron should travel at least twice the distance of the down going one. If this is not the case, it can be improved my moving the control horn on the aileron slightly backwards so that it is further back in relation to the aileron hinge point. The Rapide looks great floating along in slow cruise, but in this configuration is very prone to adverse yaw when aileron is applied. This will not show up so much if there is adequate differential in the ailerons. Do not use aileron-rudder coupling in the Rapide. Gentle turns are best entered using rudder only, or very little aileron. When into the turn, there is a tendency for the bank angle to increase. This is corrected by applying slight opposite aileron while at the same time maintaining some rudder in the direction of the turn. This is how old time planes flew at slow cruise. It is just that modern day pilots often don't learn what a rudder is for, and while maintaining a gentle turn, aileron-rudder mixing is NOT what is wanted. Learn to fly with the thumbs rather than the computer radio.

The Rapide is not intended to be a pattern plane, but it does very nice loops and stall turns. Forget about aileron rolls with ailerons as shown on the plans, but loops are very interesting. They should be started with a slight dive and gentle pull up. Nearing the top of the loop, the model may look like it is losing speed, but the couple resulting from the low thrust line in relation to the wings, results in a pitching moment that helps the Rapide pull over the top of the loop in a graceful manner at very low speed.

Have fun flying you Rapide. Ivan Pettigrew

Summary D.H. 89 Rapide
Designed 1994 Scale 1/7.5 . Span 76 ins. Wing area 1100 sq ins. Length 56 ins. Originally powered with two 27 turn Kyosho car motors, stock, wired in series from 14 cells, driving 11 x 7 props through 2 1/2:1 ratio Master gearboxes. Thrust 50 oz static at 5,800 RPM on 18 amps. Weight 113 ozs on wheels, 125 oz on floats. To save weight and achieve slower more realistic flight, the same motors were later wired parallel from nine RC-1700 cells. with Master Airscrew 3 1/2:1 gearboxes driving 11 x 9 Master airscrews. Static thrust is 40 ozs at 5,200 RPM on 24 amps, equivalent to 12 amps each motor. Weight with nine cells 97 ozs on wheels. Recommended upgrade is two Magnetic Mayhem motors in parallel from nine cells turning 11 x 7 APC-E props 6,000 RPM through 3:1 ratio gearboxes. Static thrust 52 ozs on 32 amps, 16 amps to each motor.

Rigging. Worth noting

Sent: Saturday, January 31, 2009 10:48 AM
Subject: Rigging.

Hello Ivan,

Just having a read at your bit about the DH86 Express that you have built. You mention about rigging the aircraft being time consuming and therefore requiring inherent strength in the wings.

We have just come up with a system of rigging that may interest you and other bi-plane builders. Have a look on our website (link below) and look at the WHAT'S NEW page, have a read and see what you think.

We will be uploading some principle diagrams of the system soon, it really is something to blow your mind with bi-planes.

Kind Regards

Eddie & Judy Stocker
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